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Numerical simulation of motility patterns of the small bowel. 1. Formulation of a mathematical model

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Abstract

A complete mathematical model of the periodic myoelectrical activity of a functional unit of the small intestine is presented. Based on real morphological and electrophysiological data, the model assumes that: the functional unit is an electromyogenic syncytium; the kinetics of L-type Ca2+, T-type Ca2+, Ca2+-activated K+, voltage dependent K+ and Cl- channels determine the electrical activity of the functional unit; the enteric nervous system is satisfactorily represented by an efferent cholinergic neuron that provides an excitatory input to the functional unit through receptor-linked L-type Ca2+ channels and by an afferent pathway composed of the primary and the secondary sensory neurons; the dynamics of propagation of the wave of depolarization along the unmyelinated nerve axons satisfy the Hodgkin-Huxley model; the electrical activity of the neural soma reflects the interaction of N-type Ca2+ channels, Ca2+-activated K+ and voltage dependent Na+, K+ and Cl- channels; the smooth muscle syncytium of the locus is a null-dimensional contractile system. With the proposed model the dynamics of active force generation are determined entirely by the concentration of cytosolic calcium. The model describes: the mechanical excitation of the free nerve endings of the mechanoreceptor of the receptive field of the pathway; the electrical processes of the propagation of excitation along the afferent and efferent neural circuits; the chemical mechanisms of nerve-pulse transmission at the synaptic zones; the slow wave and bursting type electrical activity; cytosolic calcium concentration; the dynamics of active force generation. Numerical simulations have shown that the model call display different electrical patterns and mechanical responses of the locus. The results show good qualitative and quantitative agreement with the results of experiments conducted on the small intestine.

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